# Coupled applications NAPS & Lewis models

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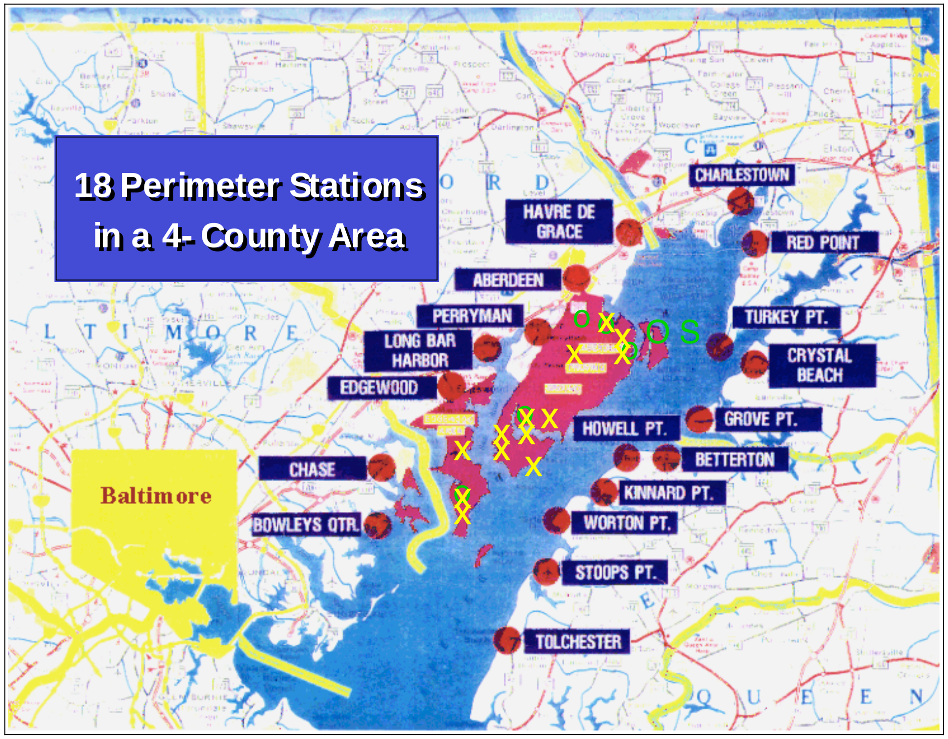
# APG layout

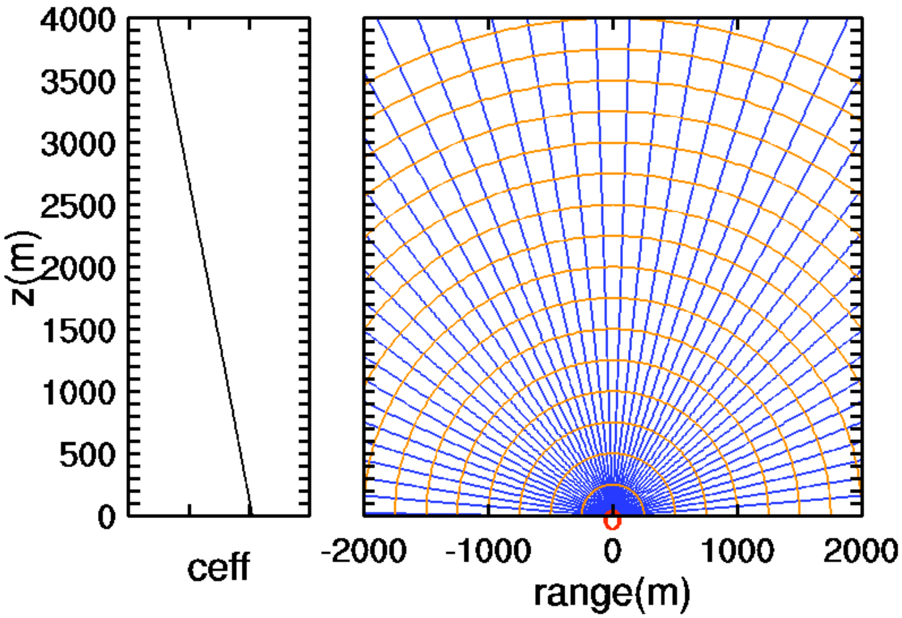
- 15 blast sites (x)
  - Tanks
  - Howitzers
  - Explosive detonations
- Meteorological observations
  - 6 surface observation stations (o)
  - 1 upper air observation station (o s)
- 18 microphone locations (●)

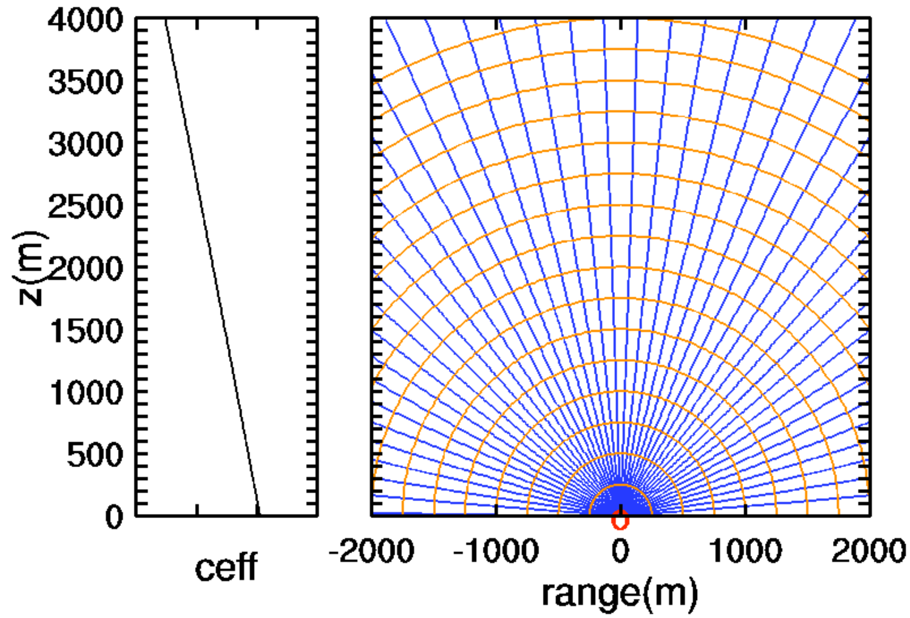


# Background

- Sound propagation depends on effective speed of sound, controlled by:
  - Temperature stratification
  - Wind and wind shear
  - Ground absorption/reflection properties
  - Air absorption
  - Scattering by turbulence

# Uniform atmosphere - wavefronts and rays

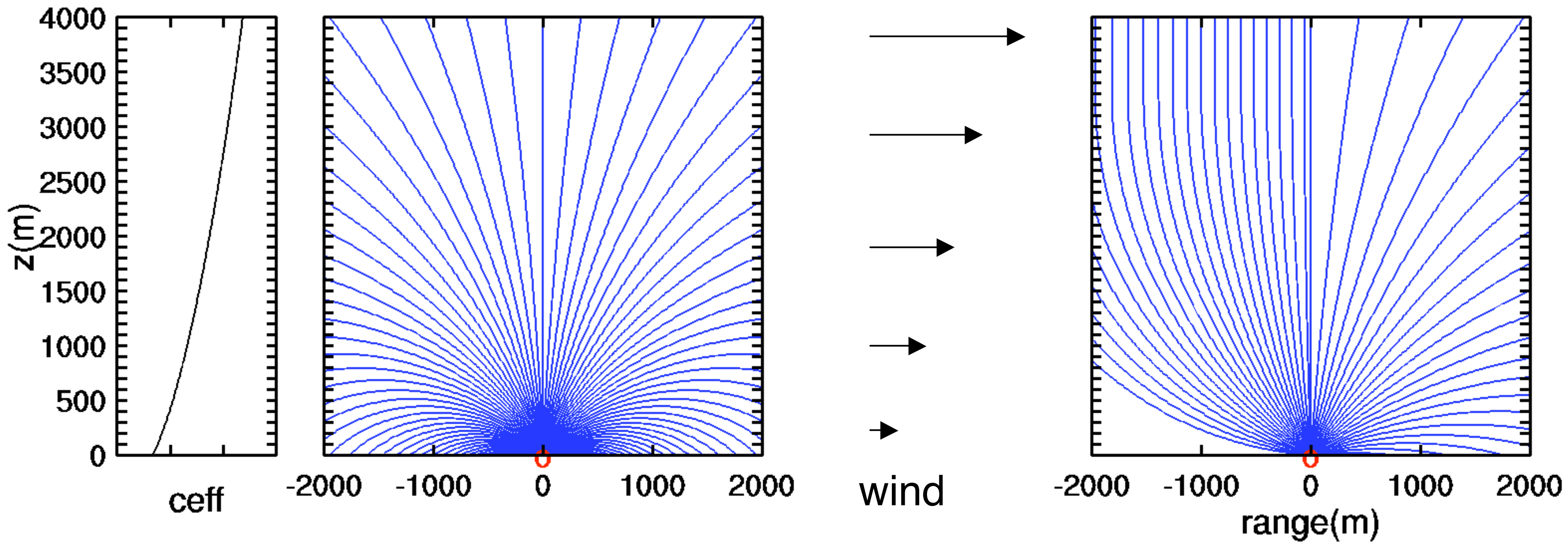



**Standard atmosphere + 0 winds**

**Standard atmosphere + 20 m/s east wind**

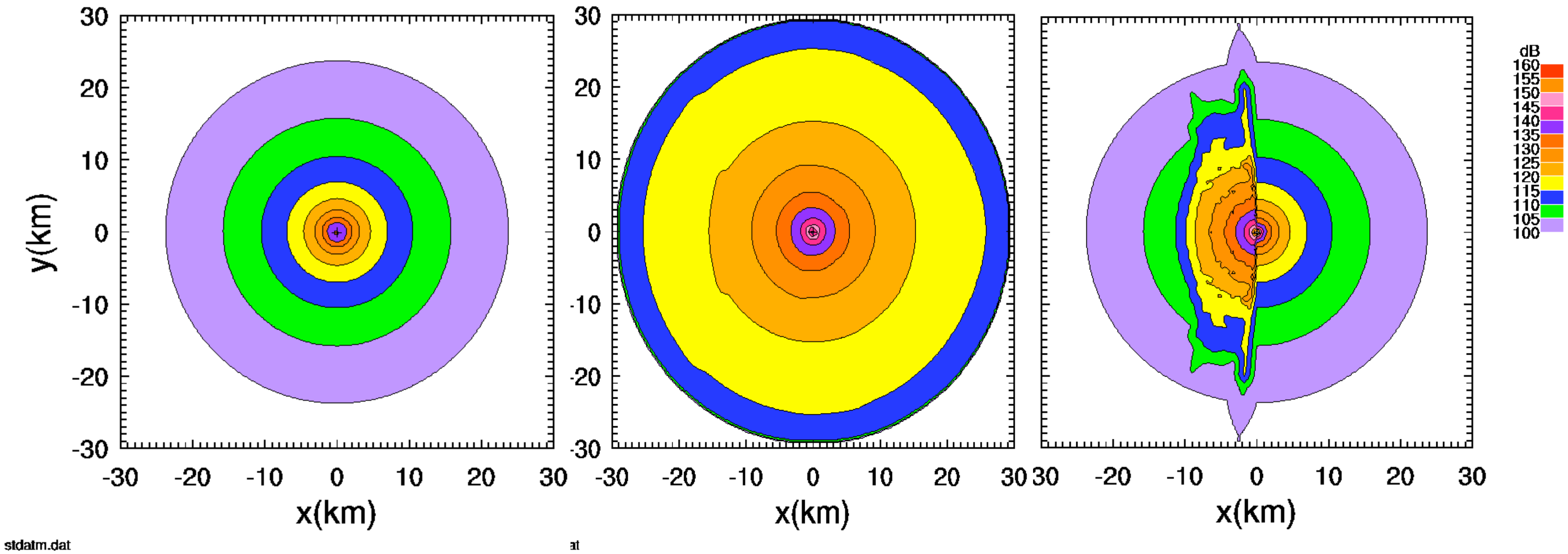
# Effect of temperature inversions and wind shears




**Temperature inversion (0.8C/km) + 0 winds**

**Standard atmosphere + west wind shear**

# Background: Effect of temperature inversions and wind shears on sound propagation

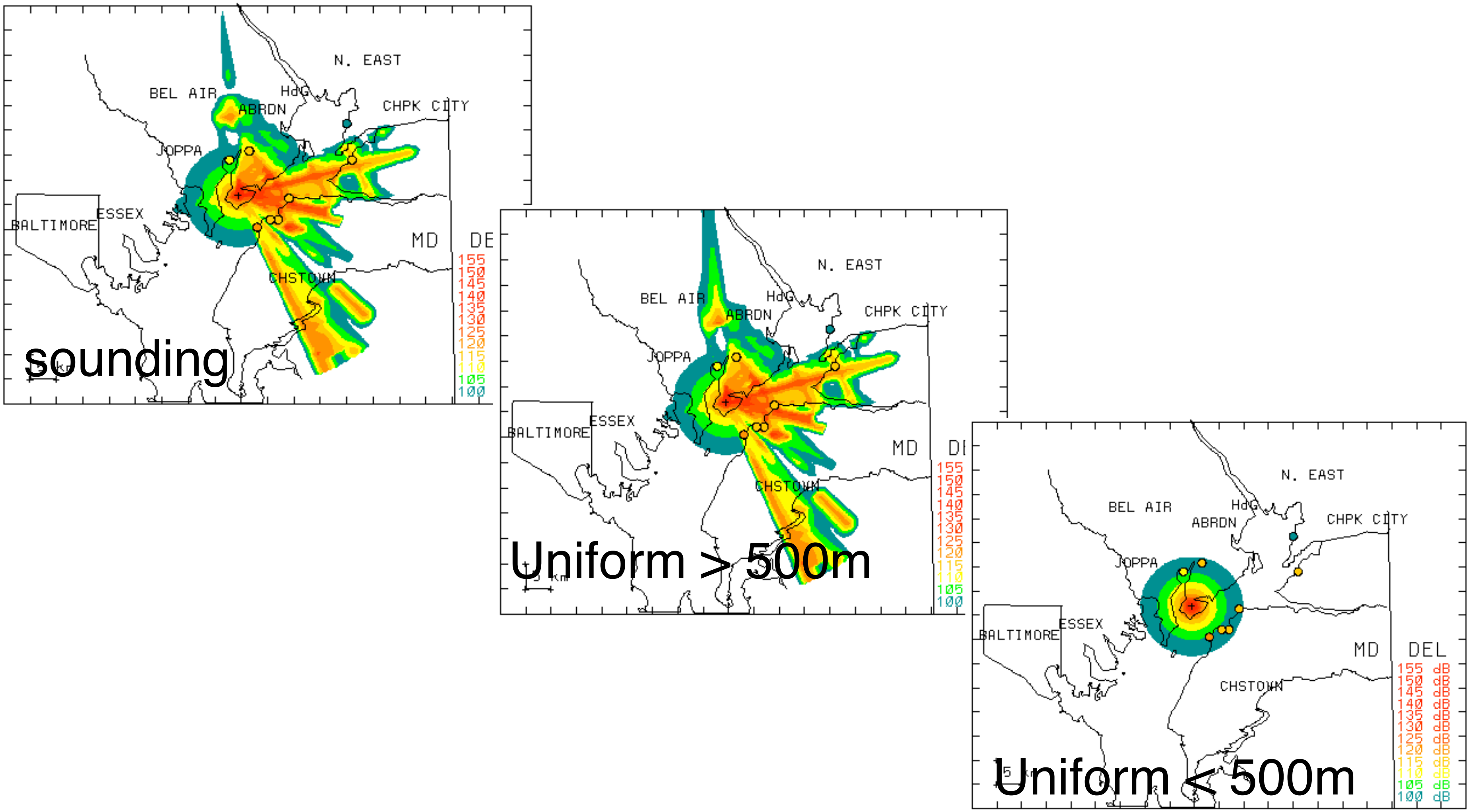



Standard atmosphere + east wind

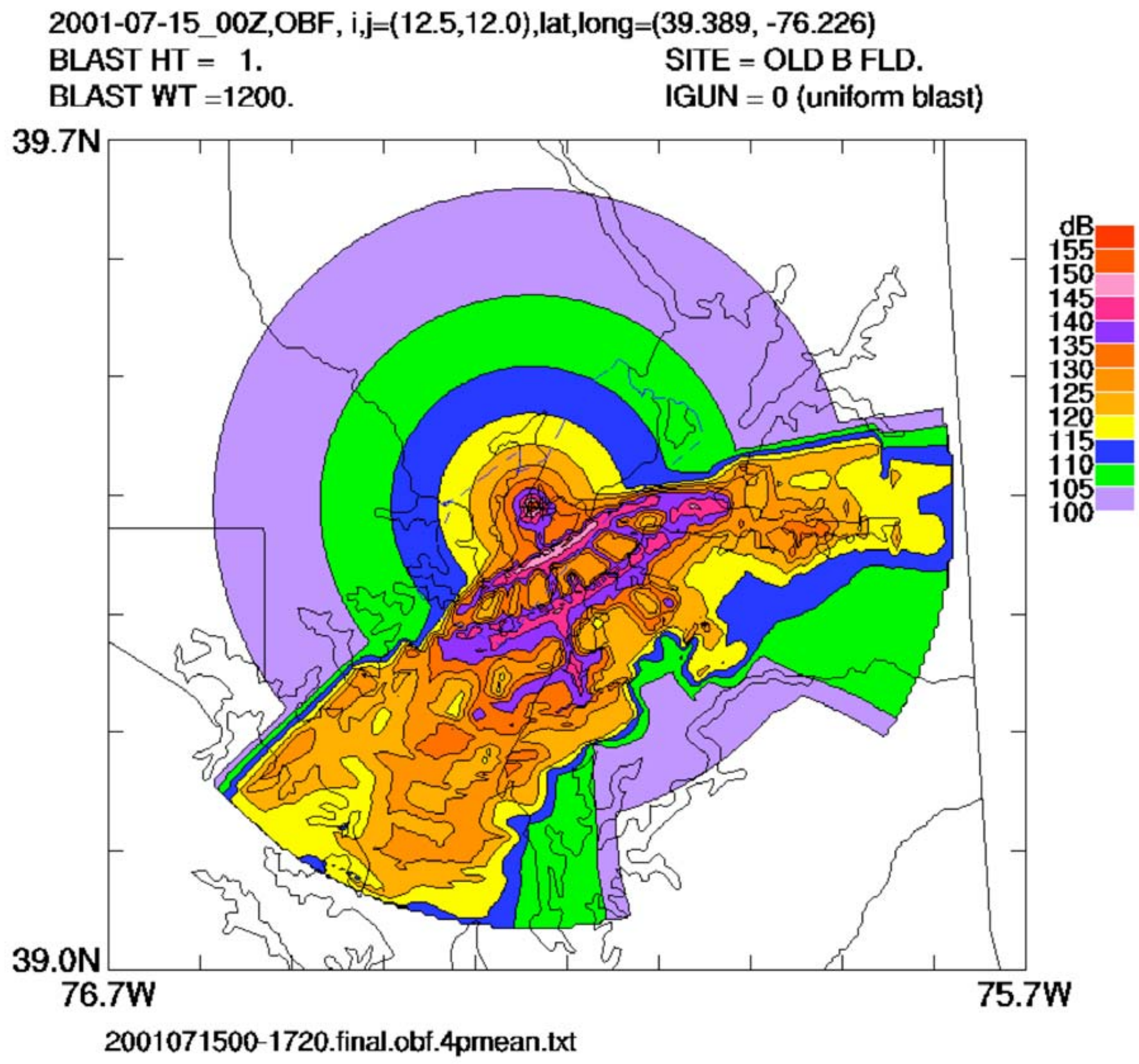
Temperature inversion + east wind

Standard atmosphere + east wind shear

# Effect of temperature inversions and wind shears (cont.)

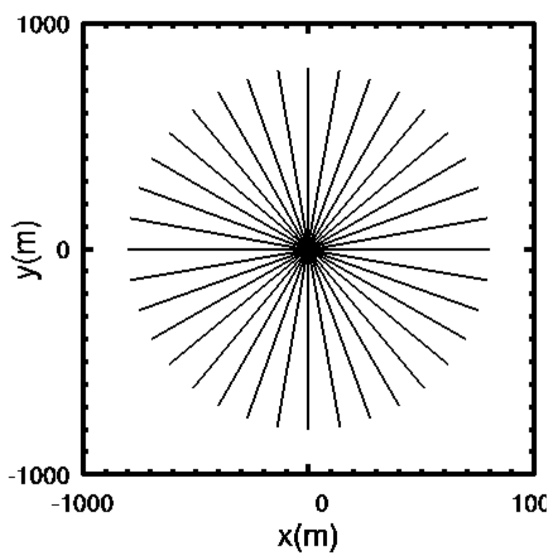


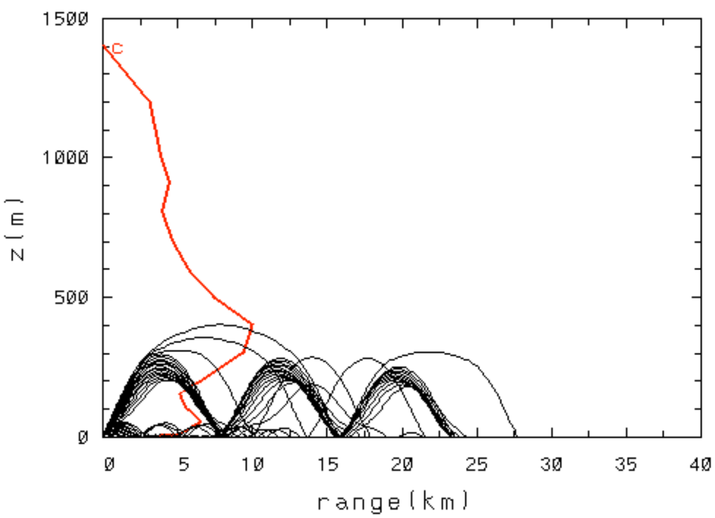
# 68 hour animation

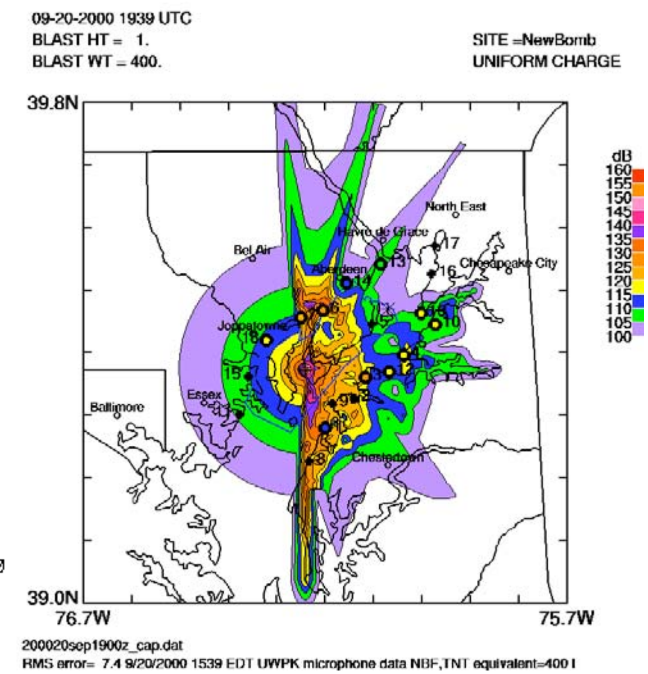


# APG Procedure

- Use sound propagation model (Noise Assessment Prediction System – NAPS)
  - Acoustic ray-tracing package
  - Predicts peak overpressure
  - Includes terrain, surface contrasts
  - Input 1 sounding
  - Computes sound rays in azimuthal planes
  - Merges planes together to provide sound level (dB) contours
- In use since early 1990s

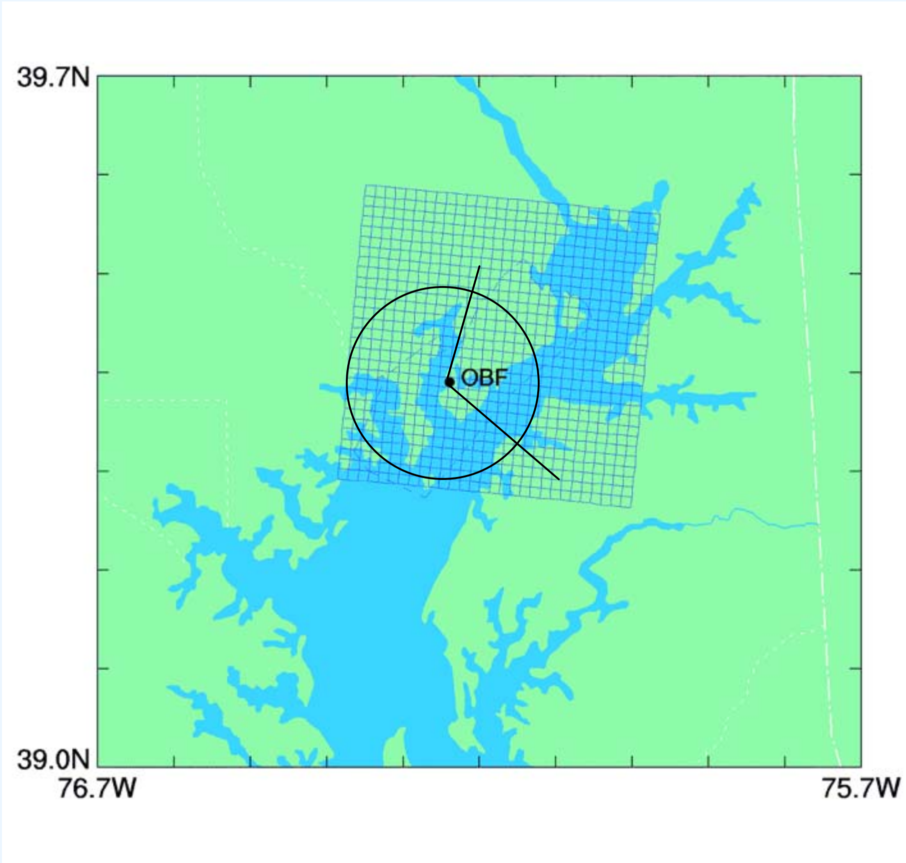


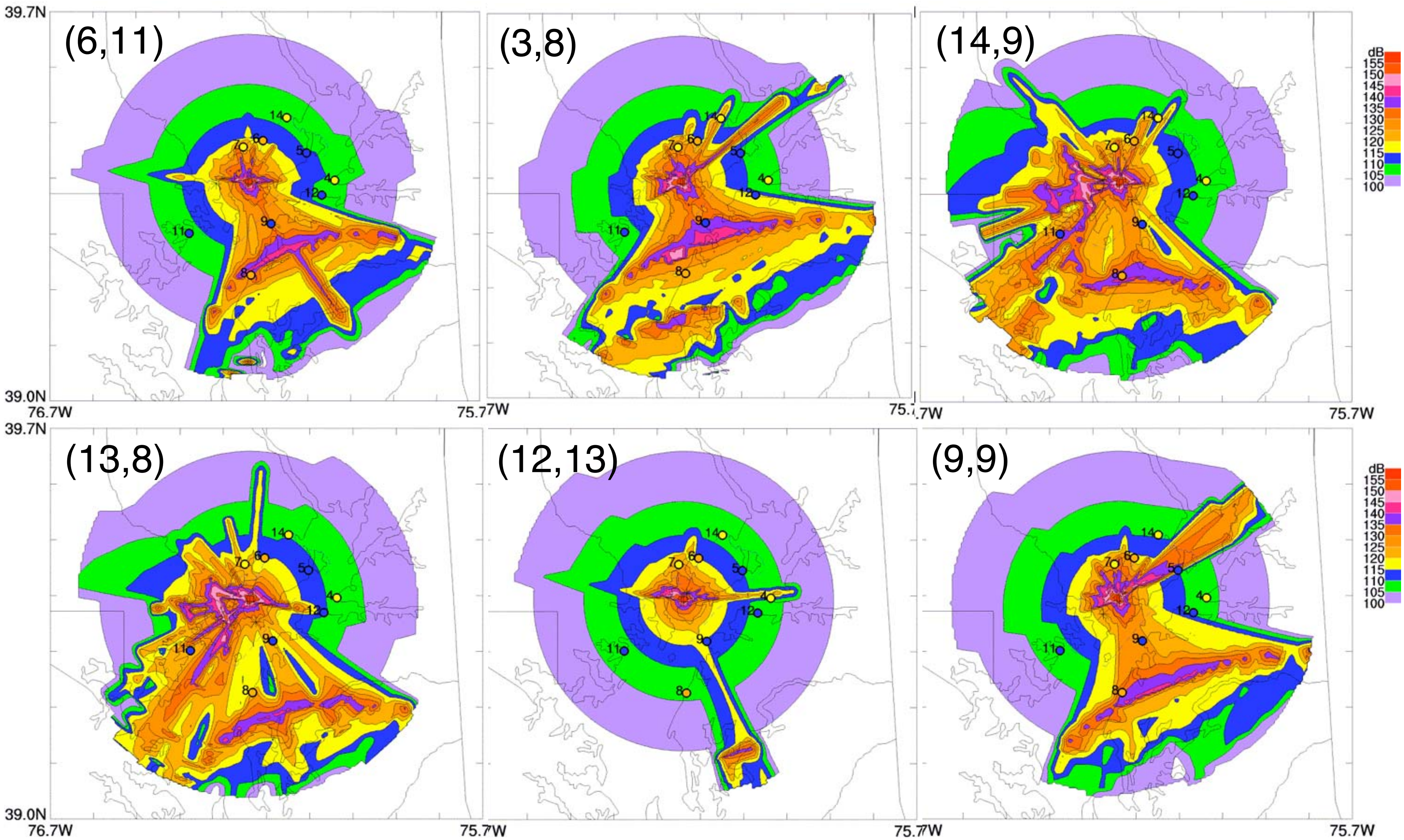
# Coupled MM5-NAPS spatial ensembles

- Uncertainties in timing/location of mesoscale phenomena (e.g., sea breeze front) can lead to substantial gridpt-gridpt differences in MM5 pseudo-soundings
- Use spatial ensembles to account for these uncertainties
- Spatial ensemble consists of all pseudo-soundings within specified radius of blast site

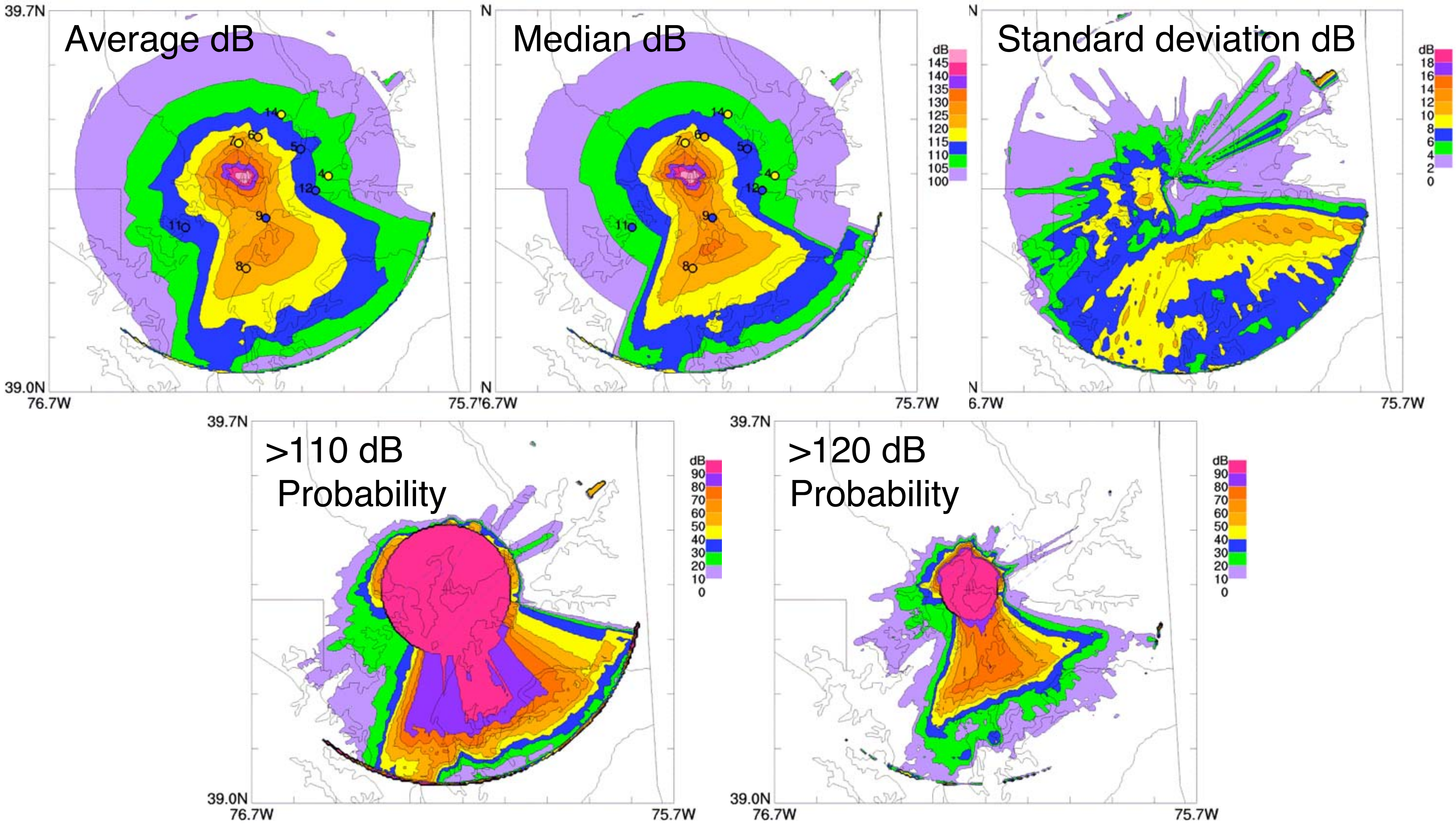



NCAR

# Coupled MM5-NAPS spatial ensemble example



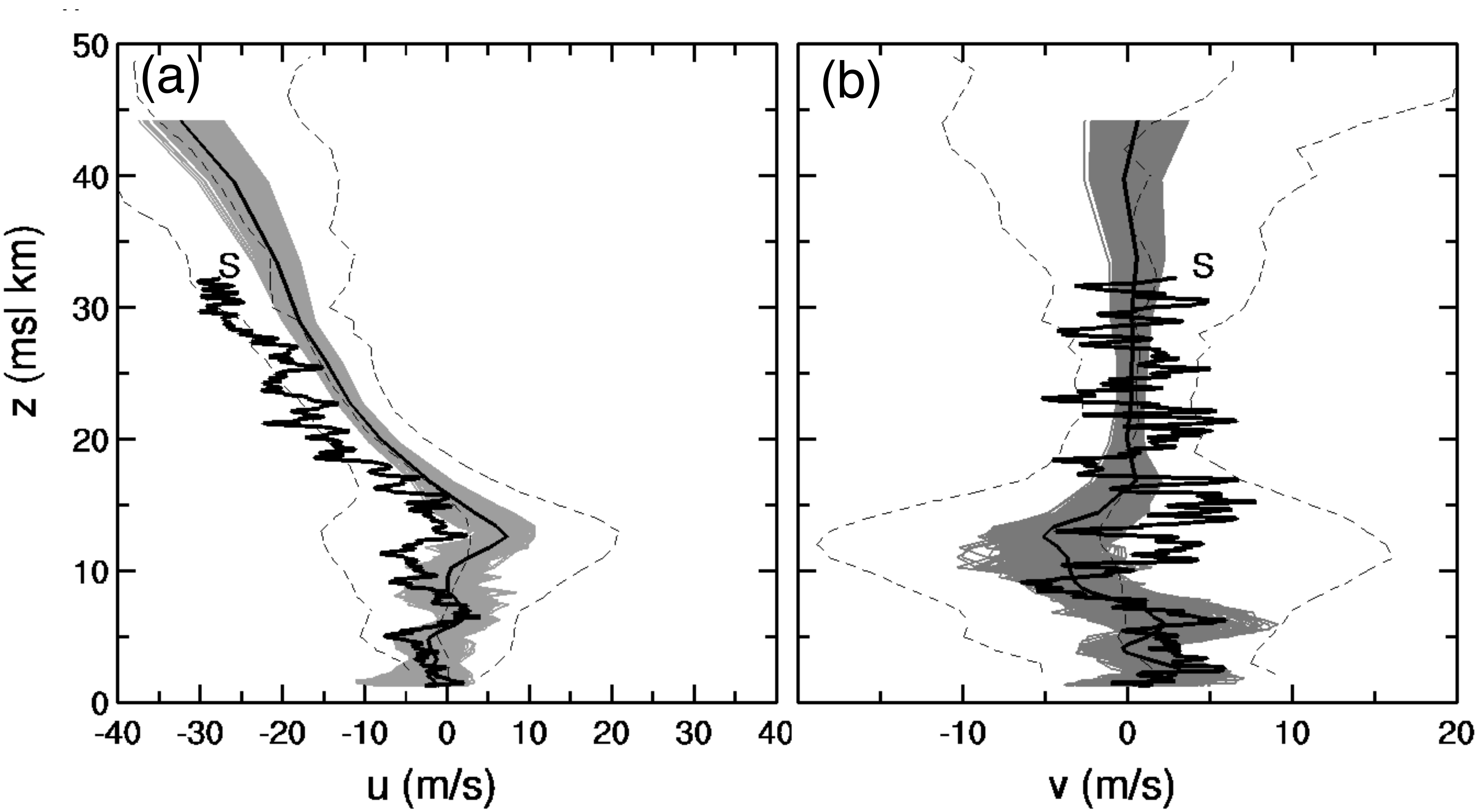
# Coupled MM5-NAPS spatial ensemble example (cont.)



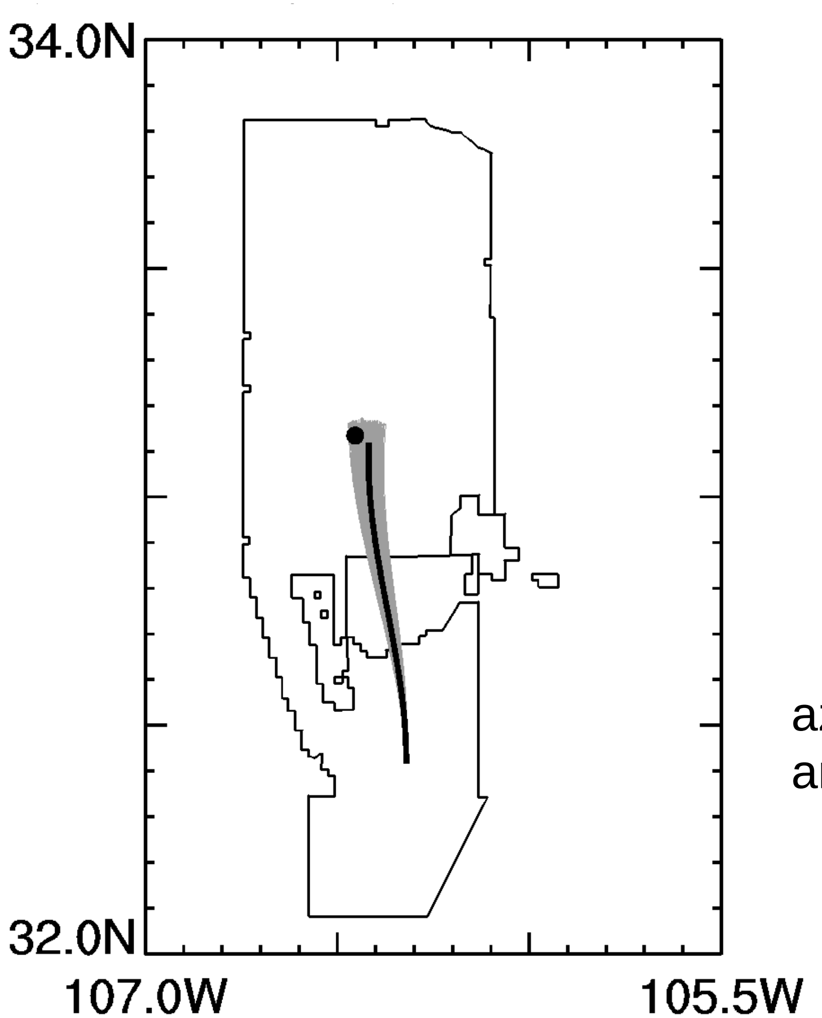
# Lewis trajectory model

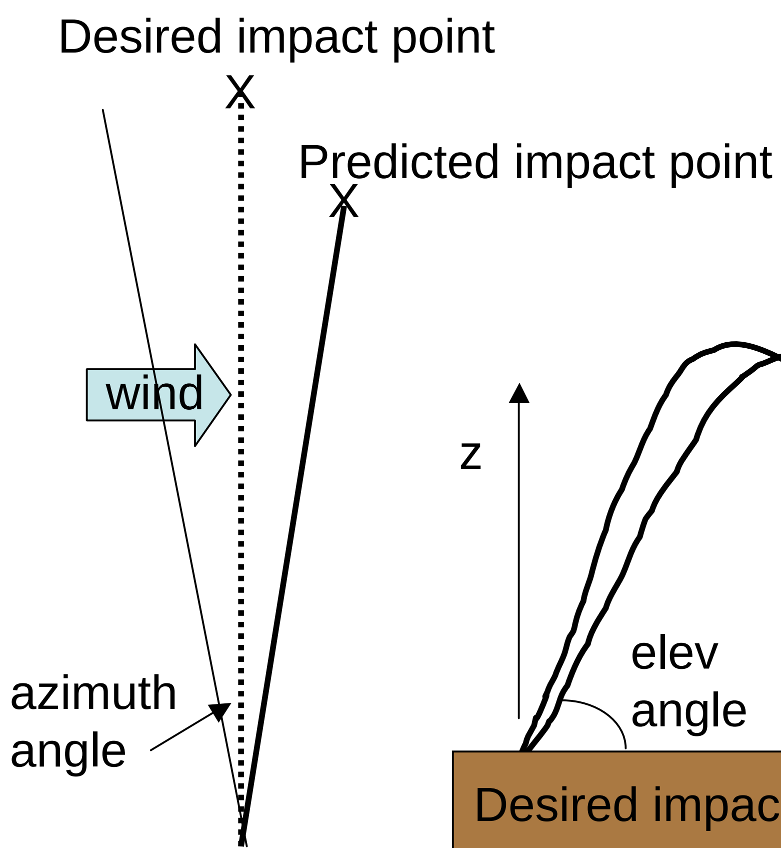
- Inputs
  - RTFDDA winds
  - Month-specific RRA winds
  - Desired vertical resolution (layer.dat)
  - Rocket specific files (*.ini, *.txt)
- Processing
  - Merge RTFDDA winds with RRA winds
  - Use Lewis method to compute downtrack and crosstrack deflections
- Outputs
  - Merged winds, trajectory (booster + sustainer)
    - plots
    - output files (winds.dat, *.trj)

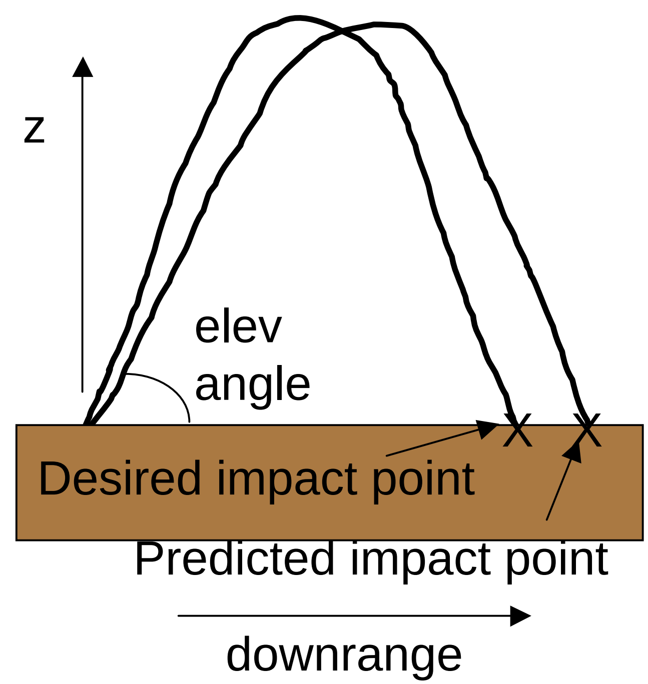
# Example of RTFDDA-RRA wind merging (spatial ensemble)



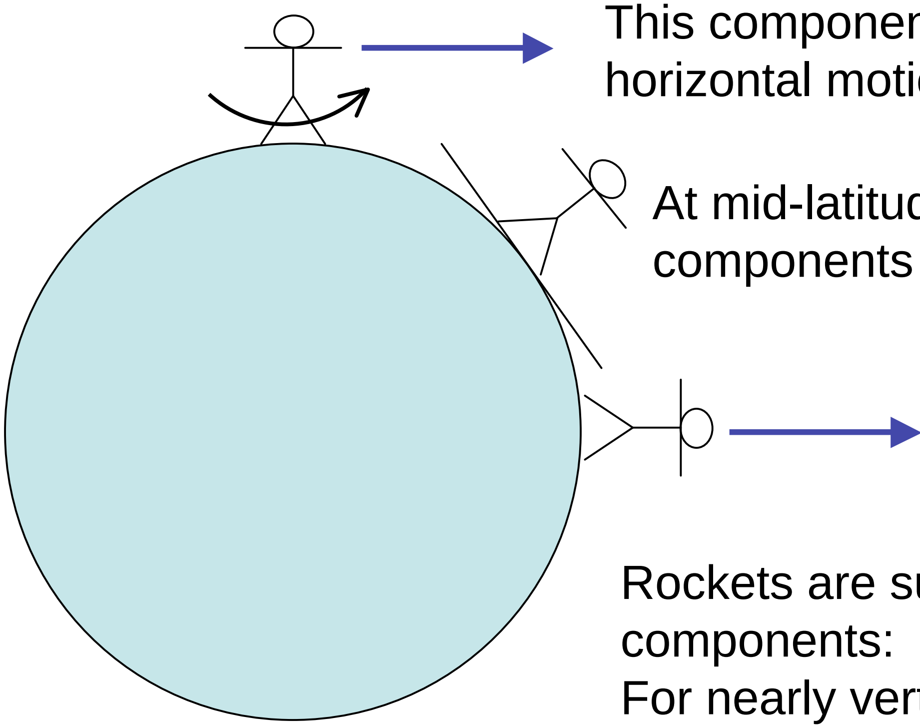
# Lewis trajectory model – used to adjust azimuth and elevation launch angle



# Note: Coriolis deflection has 2 components



This component (vertical) affects horizontal motions (e.g. winds)

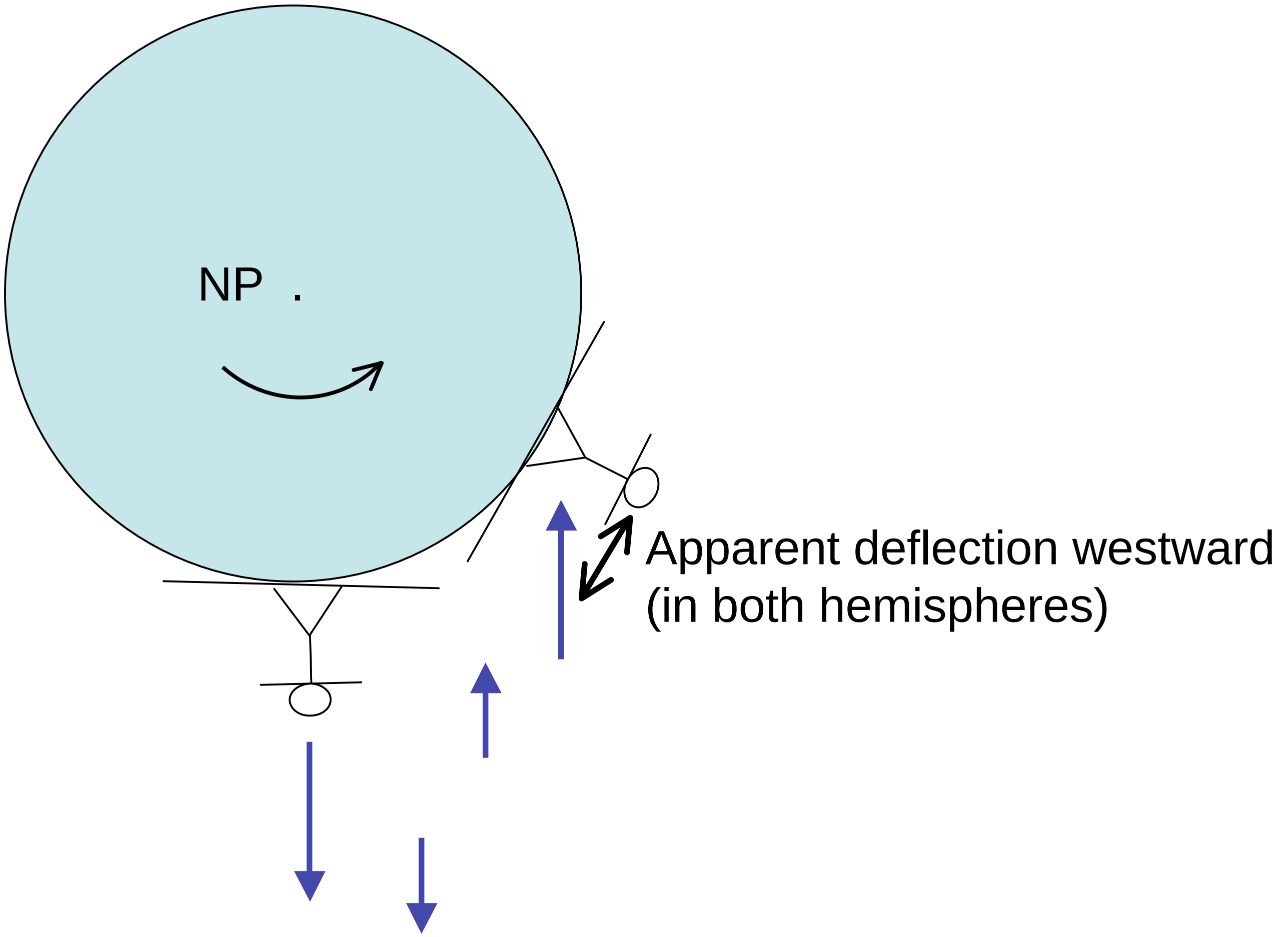
At mid-latitudes there are both components

This component (horizontal) affects vertical motions

Rotating earth

Rockets are subject to both components:
For nearly vertical launches horizontal component dominates and apparent deflection is to west in both hemispheres
For nearly horizontal launches deflection is to right in N. hemisphere, to left in S. hemisphere
In practice, sounding rockets are nearly vertical so horizontal component is the larger effect.

# Coriolis deflection on vertical projectile

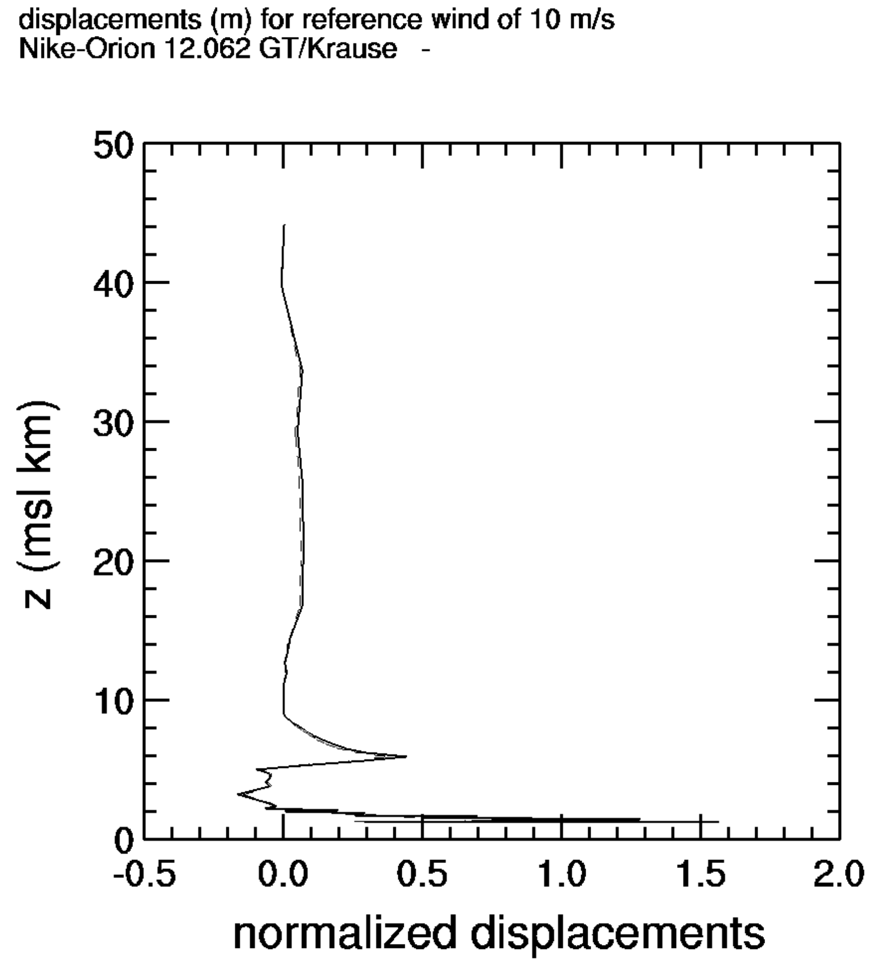


# Lewis method

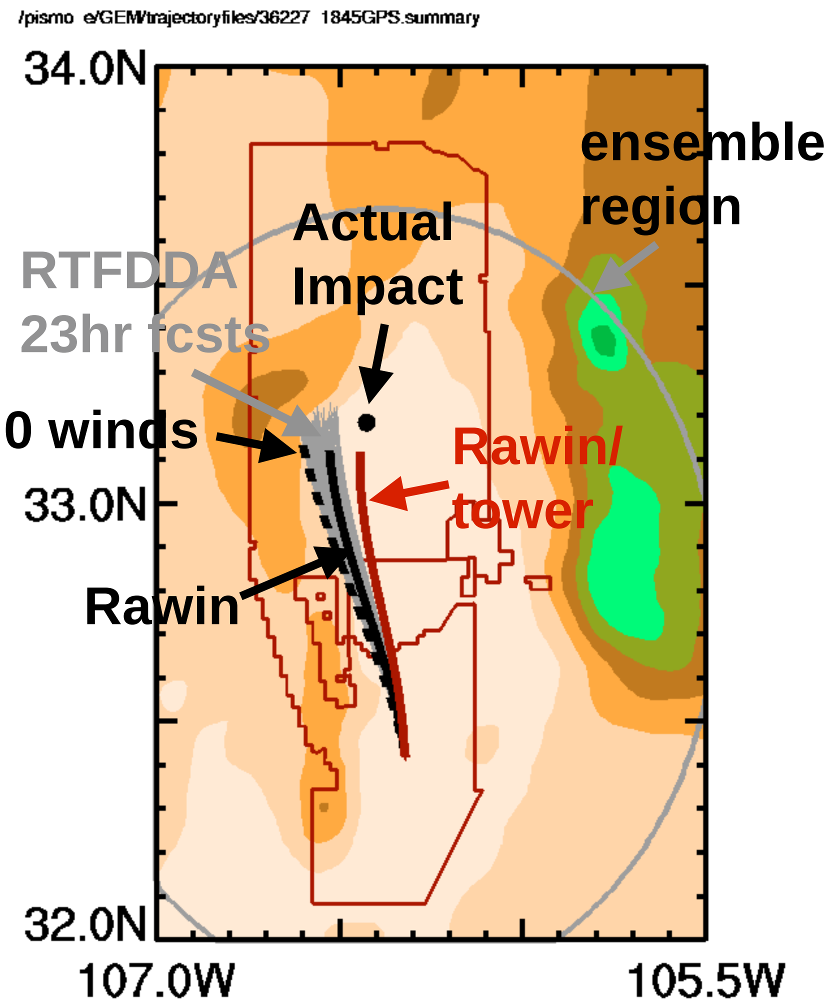
- Given winds, compute wind displacements crossrange (i=1), downrange (i=2)

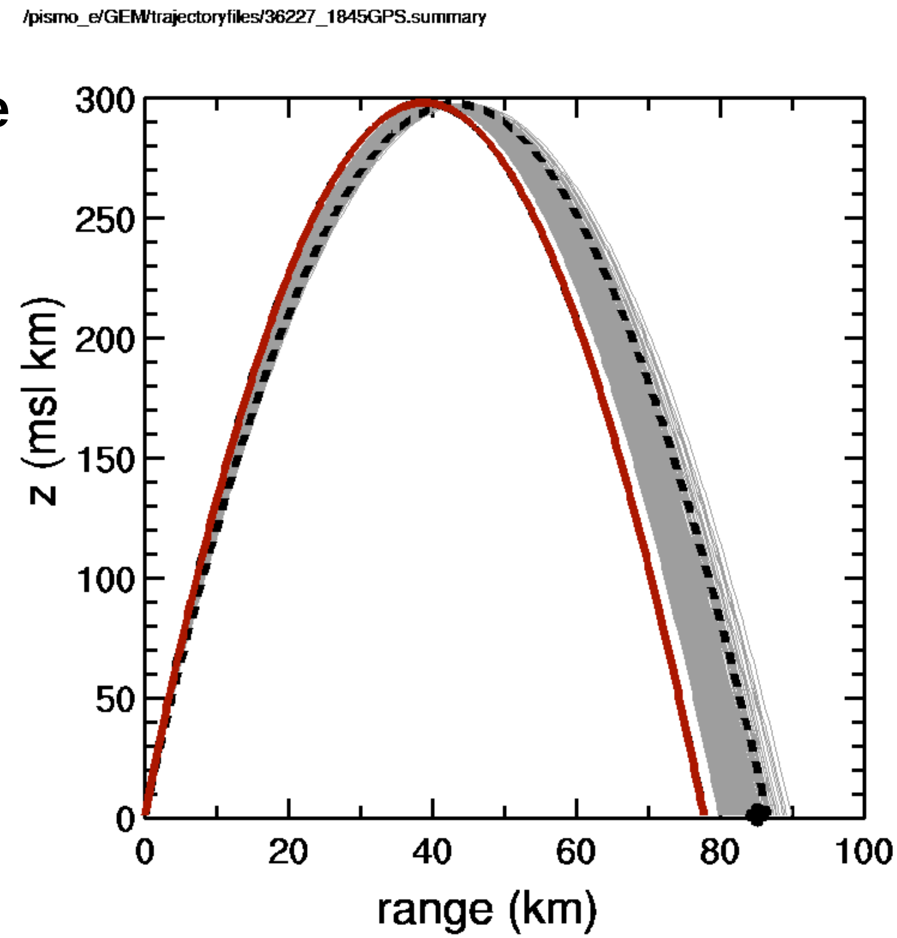
$$d_i = \int u_i(z) \frac{\Delta F_i}{\Delta z} C_i \Delta z$$

- Subtract displacements from no wind displacements
- Add in Coriolis deflections
- Compute corresponding azimuth and elevation angles



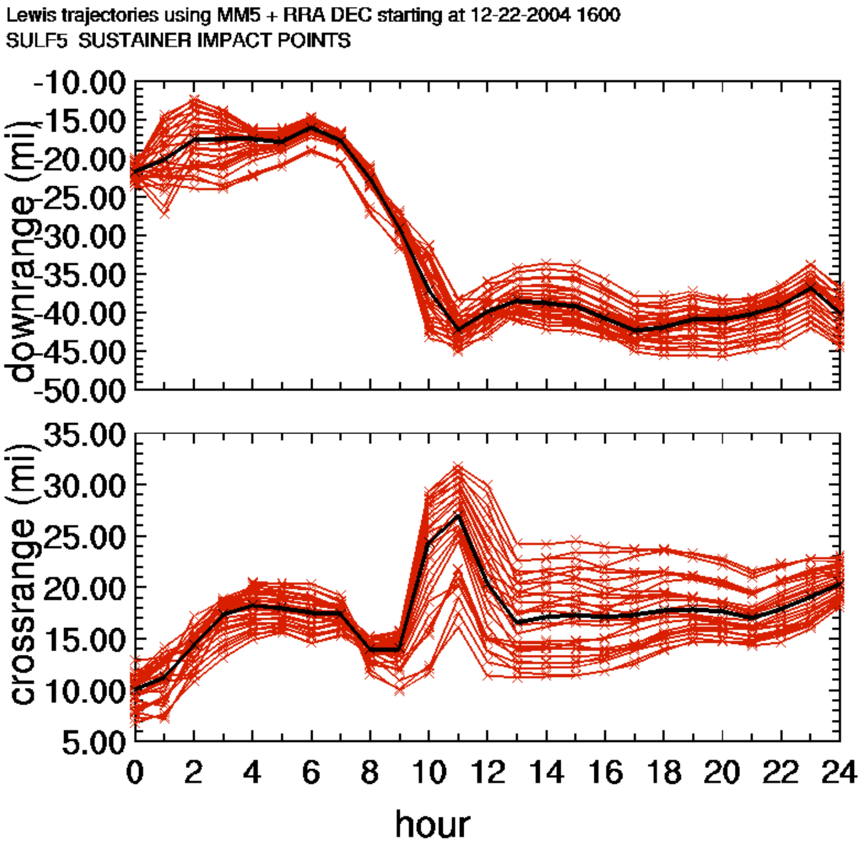
# RTFDDA-GEM/Lewis spatial ensembles

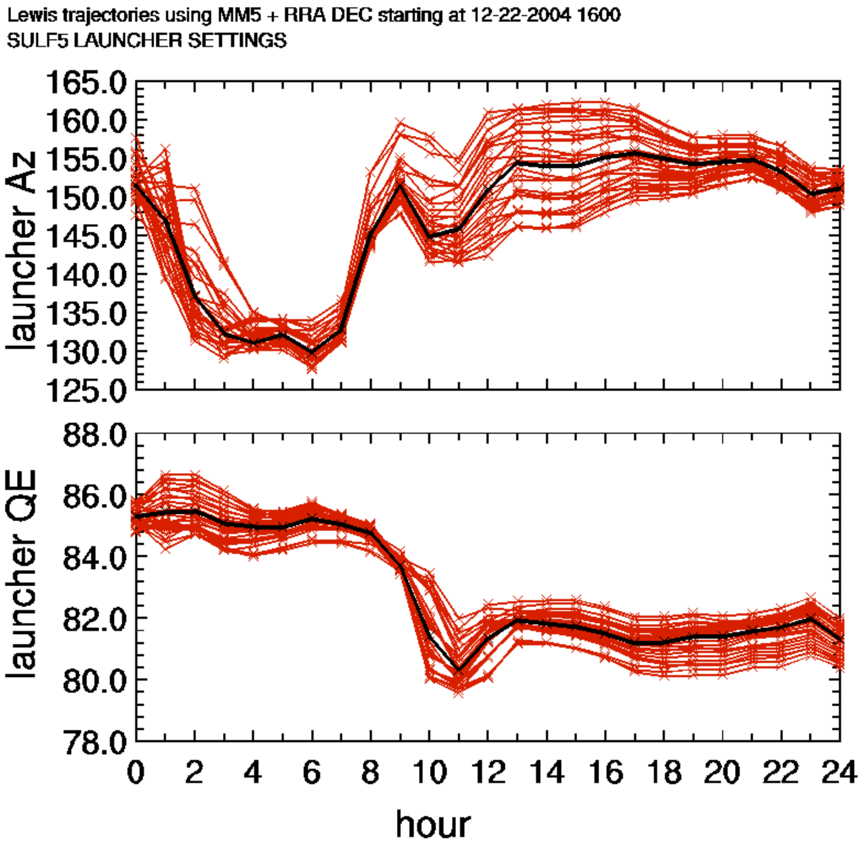



362.27 launch 3Aug2005 1845 UTC

# Lewis time history plots



# Lewis output plots – impact scatter